

ESTIMATING WILLINGNESS TO PAY FOR PROTECTION OF EASTERN BLACK WALNUT FROM DEER DAMAGE

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Abstract.—For many landowners willing to plant trees, one of the biggest establishment and maintenance costs is protecting those young trees from deer browse damage. In some cases, the method of protection used can cost two to three times as much as the cost of planting. Deer damage such as nipping off terminal buds and buck rub penetrating the bark and cambial tissue can kill young trees or cause substantial degradation in future log quality and value. An estimate of landowners' willingness to pay for damage abatement, or willingness to accept deer damage can indicate the economic impact that deer populations have on timber investment. Returns to investment are dramatically reduced when excessive costs for deer abatement are compounded to a future harvest. Three black walnut plantations are analyzed to determine the amount of deer damage present, and the costs of deer protection methods. Two methods of estimating willingness-to-pay are used. Hypothetical levels of deer damage are used to calculate estimated costs of protection methods. These costs of protection are then discounted to a present value to compare the reduction in present value caused by increased levels of deer protection. A second method, the damage cost method, uses net present value analysis to determine the difference in net present value of a plantation with no damage and one with maximum deer damage. This difference in net present value reflects the maximum willingness to pay for deer protection. Several scenarios are analyzed to estimate a landowner's willingness to pay for deer protection or willingness to accept deer damage. The results indicate that the willingness to pay for abatement on a plantation of black walnut that is established for nut production is higher than on a plantation established for timber production.

INTRODUCTION

In Missouri, one of the biggest expenses incurred when establishing a plantation is protection of trees from white-tailed deer (*Odocoileus virginianus*). In some cases the cost of protecting young seedlings can be as much as 10 times the cost of the seedling itself. There are numerous ways of protecting trees from deer damage, such as fencing, scare devices, deer repellent, and various other methods (Pierce and Wiggers 1997, Scott and Townsend 1985). However, the cost and the effectiveness of each of these methods can vary tremendously. One particular study of wildlife damage on the apple (*Malus* spp.) industry in the Hudson Valley region conducted in 1986 estimated that wildlife damage cost each grower an average of \$12,500 per year, with almost half of this cost in wildlife control measures (Phillips and others 1987). As deer herds increase, the probability of deer damage on orchards and other plantations increases. One question that many landowners ask is "What is the best method for preventing deer damage on trees?", and "Is it worth my investment or time to do this?" The answer to this question depends on the landowner's goals and objectives for that particular plantation, the type of tree species being planted, and the risk of deer damage to the trees.

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OBJECTIVES

The focus of this study is on the cost of deer damage on eastern black walnut (*Juglans nigra* L.) in Missouri. Much emphasis has been placed on the production of black walnut for potential income from both nuts and timber. White-tailed deer (*Odocoileus virginianus*) can cause serious damage to young black walnut trees by nipping terminal buds and by rubbing the bark and subsequently damaging cambial tissue of juvenile trees. This threat presents a problem to growers of black walnuts who are interested in producing a high-value timber crop. Nipping the terminal bud from the terminal leader and lateral branches of a black walnut can postpone the financial maturity of the tree 8 to 10 years and in some cases eliminate any possibility that the tree will produce a veneer-quality butt-log. In a worst-case scenario, deer browsing can actually kill a young tree. Deer rub can be almost as devastating to a young plantation because bark is often stripped from the tree, exposing cambial tissue. Wounds caused by deer rub can cause log and lumber value degradation or become an entry point for diseases. For growers who are interested in a nut crop, deer browsing can set nut production back by as much as 10 years and destroy high-value grafted stock. Although deer rub has less impact on nut production, it can create a wound on a tree that will allow entry points for disease and insect pathogens.

This study looked at existing stands of eastern black walnut trees at various ages to determine the probability and severity of deer damage. These estimates were then used to reflect the potential damage without deer protection. The objective of this paper was to calculate expected net present value of the timber stand with and without deer damage in order to estimate a landowner's imputed willingness to pay for deer protection for young trees, or in most cases, the imputed willingness to accept deer damage. The economic concept of willingness-to-pay should not be confused with the idea that the landowner is actually required to make a payment. The idea of willingness-to-pay and willingness-to-accept simply reflects the level of consumer or producer surplus that can be exchanged to reach a Pareto optimal level where the individual is no better or worse off (Just and others 2004). For this paper, willingness-to-pay and willingness-to-accept are estimations of the potential economic surplus that could be used to prevent deer damage, whether paid or accepted. It is estimated that willingness-to-pay will vary depending on the age and purpose for growing the trees. One expected outcome from this paper is to provide a range of economically feasible costs for landowners growing black walnut for nuts or timber.

STUDY AREAS

Several black walnut plantations of various ages were located in central Missouri as study sites. Site A is located approximately 15 miles east of Columbia, MO, in Boone County. The trees on site A are between the ages of 5 and 15 years old and planted in east-west rows. Site A has two distinct stands. Stand 1 consisted of 15-year-old trees. Stand 2 consisted of trees ranging in age from 5 to 10 years old. Site A had been managed with moderate pruning and weed control. The landowner's objective for growing the trees is for future timber income. None of the trees on Site A had been protected from deer damage.

Site B is located approximately 80 miles west of Columbia, MO, in Carroll County. This site consisted of 7 acres of 24-year-old black walnut that had been originally planted at a density of 300 trees per acre. According to the landowner's records, 180 trees had been completely destroyed in the first 5 years of the plantation due to deer damage. The tree rows run north and south and the trees are on 12.0- x 12.0-ft. spacing. The trees on this site are being grown for future timber income and have been managed with pruning and occasional weed control. Similar to Site A, none of the trees on this site have been protected from deer; however, the site is regularly hunted.

Site C is located about 2 miles west of Columbia, MO. It consists of numerous stands of trees varying in age from 5 to 30+ years of age. It appears that the original spacing on most of the stands is 10.0 x 10.0 ft. Site C had small stands of equal age, and row arrangement varied with the contours of the site. Some stands have rows that run north and south and some stands have rows that run east and west. Most of the younger trees were protected with wire cages and metal T-posts. Older stands were not protected at the time of inspection. Some pruning had been conducted on the stands; however, no weed control was evident. The landowner's goal for planting the trees is for a future timber income.

METHODS

Random samples of 50 trees per stand at sites A and B, and 25 trees per stand at site C were selected by transecting the stand across rows, working from one outside edge to the opposite outside edge. The data collected consisted of diameter at breast height (d.b.h.) in inches measured with a diameter tape; height in feet measured with a Laser Technology, Inc laser hypsometer; and a subjective estimate of value damage caused by deer activity. Estimates were also made regarding trees that had the potential for future veneer quality logs. This estimate was based on form, number of clear faces, visible defects, and branching characteristics. In order to estimate deer damage, a value judgment was made based on the following four criteria:

1. Critical Value Damage. Damage to the tree will cause or has caused the tree to die. Stump sprouting may be evident, but the damage most likely has been fatal (Fig.1, A).
2. Severe Value Damage. Damage to the tree will not be fatal, but the tree has been set back several years and survives through extensive stump sprouting (Fig. 1, B).
3. Moderate Value Damage. Damage to the tree has caused a wound that will take several years to heal over. Value has been degraded (Fig. 1, C).
4. Light Value Damage. Damage to the tree is superficial and will heal over; however, some value may be lost (Fig. 1, D).

It should be noted that there were other causes of damage on the trees including insect damage, frost cracks, mower/equipment damage, and fungal diseases. However, only the damage that was consistent with typical deer browse and rub was considered.

To calculate a landowner's willingness to pay for deer control, equations 1 and 2 were used to estimate the opportunity cost of deer damage:

$$WTP = NPV_{no\ damage} - NPV_{with\ damage} \quad (\text{eq. 1})$$

and,

$$NPV = \sum_{i=0}^n \frac{R_i}{(1+r)^i} - \sum_{i=0}^n \frac{C_i}{(1+r)^i} \quad (\text{eq. 2})$$

where:

R_i = expected revenues in time period i

C_i = expected costs in time period i

r = discount rate

n = total number of time periods



Figure 1.—Examples of trees damaged by deer. Photograph A represents Critical Value Damage; B represents Severe Value Damage; C represents Moderate Value Damage; and D represents Light Value Damage.

The net present value for both timber and nut production was based on the cost and revenues per tree used in the Black Walnut Financial Model (Godsey 2006). Timber prices are based on the stumpage prices reported in the Missouri Timber Price Guide (Missouri Dept. of Conserv. 2007) and other sources:

1. Grade sawlogs - \$0.80 per board foot
2. A Veneer - \$3.50 per board foot
3. B Veneer - \$2.00 per board foot
4. C Veneer - \$1.25 per board foot

To capture the loss in value due to deer damage for the timber investment, an estimate of the potential quality of the trees was made based on the site inspections. A weighted average price per board foot was calculated and applied to the model. Table 1 shows how the price per board foot was calculated. For damaged timber trees, the weighting was adjusted to reflect the amount of damage seen on the subject sites and the price per board foot was calculated again using a weighted average value. Also, for the scenarios where damage was present, an additional cost is incorporated for replacement of critically or severely damaged trees, and expected revenues are reduced early in the production years in order to reflect lost

Table 1.—Weighted average prices per board foot for timber with and without damage

Quality	Potential revenue (No Damage)		
	bf	price	Total Value
Veneer A	981.711	\$3.50	\$ 3,435.99
Veneer B	2086.14	\$2.00	\$ 4,172.27
Veneer C	613.569	\$1.25	\$ 766.96
Sawlog	2454.28	\$0.80	\$ 1,963.42
	6135.69		\$10,338.64
			\$1.69/bf

Quality	Potential revenue (With Damage)		
	bf	price	Total Value
Veneer A	795.787	\$3.50	\$2,785.25
Veneer B	2086.14	\$2.00	\$4,172.27
Veneer C	613.569	\$1.25	\$ 766.96
Sawlog	2640.20	\$0.80	\$2,112.16
	6135.69		\$9,836.65
			\$1.60/bf

income due to damaged trees. These costs and income reductions are manually incorporated into the Black Walnut Financial Model.

Other assumptions that were used in the black walnut financial model include a diameter growth rate of 0.3 inch per year, a 50-percent removal of trees at each thinning period; management for one 16-foot log with an average d.b.h. of 24 inches, and thinning is conducted when the crown competition factor reaches 150.

None of the plantations studied were being managed for nut production; therefore, damage estimates from the study sites were applied to a hypothetical black walnut plantation that is being managed for nut production. Costs and revenues for this hypothetical black walnut plantation are based on five existing black walnut plantations that are being managed for nuts. In order to look at the impact on nut production, the following assumptions were used in the black walnut financial model. The cost per grafted seedling was \$15, and a nut price based on the average price paid to producers of \$0.35 per pound was used. The trees are also thinned when the crown competition factor reached 110; however, since the trees were not managed for timber, they were sold as sawlogs at \$0.80 per bf. Only two initial spacing levels were used in the model. These initial spacings were 25.0 x 25.0 ft. and 30.0 x 30.0 ft. based on work by Reid and others (2007). It was assumed that the plantation was being managed for either timber or nuts, not both at the same time.

RESULTS

Table 2 shows willingness-to-pay for deer damage abatement on timber plantations with initial spacings from 10.0 x 10.0 ft to 14.0 x 14.0 ft and various discount rates ranging from 3 to 8 percent. Based on the assumptions of the model, the range of values that would reflect a landowner's willingness to pay for deer abatement in a young timber stand would range from \$13.18 to about \$91.47 per acre. What this indicates is that if landowners are managing this timber as an investment and have planted the trees on 10.0 x 10.0 ft spacing, then they can invest \$91.47 per acre on deer protection and still earn a 3-percent return on the

Table 2—Willingness-to-pay for deer abatement for different initial planting densities and discount rate

Initial spacing	Discount Rates					
	3%	4%	5%	6%	7%	8%
10'x10'	\$ 91.47	\$ 56.10	\$ 38.90	\$ 30.30	\$ 25.86	\$ 23.43
12'x12'	\$ 76.54	\$ 44.76	\$ 24.92	\$ 22.08	\$ 18.35	\$ 16.39
14'x14'	\$ 80.91	\$ 45.65	\$ 28.45	\$ 19.89	\$ 15.50	\$ 13.18

Table 3.—Willingness-to-pay per acre for deer abatement in nut production given two common initial planting densities and discount rates

Initial spacing	Discount Rates					
	3%	4%	5%	6%	7%	8%
25'x25'	\$ 203.87	\$197.44	\$191.61	\$186.29	\$181.39	\$176.85
30'x30'	\$ 141.58	\$137.12	\$133.07	\$129.37	\$125.97	\$122.81

timber investment. However, if the landowners are interested in earning 8 percent on that same plantation, then only \$23.43 per acre can be spent for deer protection. This low willingness-to-pay reflects the fact that the benefit received for investing in deer protection on black walnut managed solely for timber is not justified by the cost of the deer protection. This way of thinking may be the reason that very few of the landowners throughout Missouri who are growing black walnut for timber actually spend the time and effort to protect those young seedlings.

On the other hand, landowners who are growing eastern black walnut for nut production present a different situation. Table 3 shows the willingness-to-pay for deer damage abatement for nut production at two different spacing recommendations and various discount rates. Values for willingness-to-pay range from \$122.81 to \$203.87 per acre. What this means is that if a landowner wishes to make a return of 8 percent from nut production and the initial spacing was 30.0 x 30.0 ft, it may be difficult to justify investing in deer protection for those young trees. Or, put another way, a landowner with initial spacing of 30 ft x 30 ft can invest \$203 per acre for deer protection and still earn a 3-percent rate of return on the investment. As was expected, the willingness-to-pay for deer damage abatement in a plantation being maintained for nut production is considerably higher than the willingness to pay for deer abatement in plantations managed for timber.

DISCUSSION

It should be emphasized that this study was a preliminary look at the cost of deer damage and its economic impact on the production of black walnut timber and nuts. Many risks are associated with the production of timber or any other long-term investment. Deer damage is just one such risk. While inspecting the trees for deer damage, we saw evidence of degradation not caused by deer, such as frost cracking and insect damage. In addition to these factors that affect quality, two other factors were noted that probably have the most impact: proper site selection and good genetics.

Another factor that was not considered in this discussion is the impact of good weed control on the growth of the tree and the risk of deer damage. Obviously, with good weed control a tree will grow faster, but the relationship between faster growth and the risk of deer damage is not known. For this analysis, growth rate was assumed to be a constant.

Also, the impact of deer protection on the risk of deer damage was not considered in this study. Only two samples were taken in areas with deer protection. The deer protection used consisted of wire caging. It appeared that the deer protection had no impact on the amount of damage to the trees. In fact, both stands that had the wire caging had 16 percent of the trees either critically or severely damaged and the other stand had (compared to 22 and 28 percent on Site A and 14.57 percent on Site B, both without deer protection). In many cases, the deer actually bent the wire cages to get to the tree, or pushed the wire cages over in order to reach the tree.

As was expected, the willingness to pay for deer abatement in timber production was very low. In reality, a landowner interested in planting black walnut for future timber production will start with hundreds of seedlings per acre and eventually thin to less than a hundred per acre. If deer or other wildlife destroy a third of the young seedlings, the only real loss is the cost of the seedling and labor. Some may argue that potential veneer trees may be degraded by deer damage; however, over the long-term course of the plantation those risks are minimal.

On the other hand, landowners who plant black walnut for nut production face an entirely different set of options. Nut production requires more orchard management and returns income sooner than timber production. As a result, establishment and maintenance costs are higher. The impact on income of losing both the more expensive seedlings and the years of production is greater. In many cases, landowners who are interested in nut production will have as much as \$15 per seedling invested and are expecting to generate some income from that investment as early as 10 years after planting. If deer or other wildlife destroys that seedling then the landowner is out not only the cost of the seedling but also the potential revenue starting at the tenth year and running into perpetuity. As expected, a landowner can afford to spend more for deer abatement in these types of plantations.

The objective of this paper is to determine how much a landowner should pay for deer damage abatement. Numerous methods claim to be effective at preventing deer damage, and costs range from \$40 per acre for bar soap methods to \$600 per acre for fencing (Pierce and Wiggers 1997). Although the effectiveness of many of the noncommercial methods is questionable, these methods are the very ones landowners are likeliest to use. The values calculated from this preliminary study explain why. For black walnut protection, many of the more effective methods of deer abatement are too expensive.

Future research on the cost of deer damage should focus on the impact of deer damage on timber trees from the perspective of sawmill product yield and recovery. Young trees damaged by deer may survive; however, the wounds caused by buck rub and browsing that penetrates the cambium may show up at the mill as the log is being processed. The expectation that a log removed from a plantation may have some unseen internal damage, could create a negative bias toward the value of the plantation as reflected in future prices offered for stumpage or logs.

Some of the challenges faced during this study included distinguishing between deer damage and other forms of damage. It became evident that deer are only a small risk factor when it comes to production of high- value timber. Another challenge was trying to incorporate growth factors, cost factors, and management factors over a long time period in order to get a model that would reflect reality. The Black Walnut Financial Model has many caveats; however, this type of financial analysis could not have been done without the timber growth financial analysis provided by that model.

In conclusion, this study was designed to look at the cost of deer abatement from the perspective of how much could be spent to prevent damage as opposed to looking at the discounted value of how much was actually spent. The difference between the two perspectives is determined by calculating the willingness-to-pay value. Landowners can then decide where their investment strategy falls within the range of values calculated. With a discounted cost method, the decision about the method of abatement is predetermined and the landowner is faced only with the results of selecting that method. Calculating willingness-to-pay provides more flexibility in the decision process.

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